Recreational Travel Behavior: The Case for Disaggregate, Probabilistic Models

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Increasing attention has focused recently on the advantages and properties of disaggregate, probabilistic transportation models (26, 27). These models consider the individual traveler rather than an aggregation of households within zones and use statistical tools such as discriminant analysis, probit analysis, and logit analysis to assign a probability to a traveler that he or she will make a certain travel decision. Aggregation usually occurs by using these probabilities to compute the expected number of travelers who will make this travel decision.

Although considerable experience has been gained in using disaggregate models, this experience has been almost entirely devoted to urban work trips and to the mode-choice decision in particular (28, 30). [Stopher and Reichman (26) reviewed the earlier empirical work on the use of these models.] Yet in a recent review of 46 urban transportation studies, Sajovec (23) found that 63 percent of the trips were not home-based work trips. Furthermore, as leisure time and personal income continue to increase, nonwork travel will no doubt continue to gain in importance. It is clear, therefore, that the ultimate value of disaggregate, probabilistic models depends not only on how well they represent work trips but also on how well they represent nonwork trips.

In many ways, nonwork trips represent a much tougher test of disaggregate models than do work trips. Nonwork trips are less regular both in time and space than work trips. Also, they involve a wider range of trip purposes. Yet the primary difficulty in modeling such trips lies in the fact that they are less economically motivated and more psychologically motivated. For example, inclement weather and crowded highways do not deter a person from traveling to work, yet a cloudy sky may dissuade a person from making a shopping trip or a trip to visit friends.

Among types of nonwork trips, recreational trips in particular are both interesting and challenging to model. They are perhaps the most dependent on psychological motivations, and they sometimes show a strong disregard for distance. [Burch (1) examined the psychological motivations underlying recreation, and Wolfe (33) showed distance to vary drastically in importance among different types of recreational trips.] Witness, for example, trips of several hundred miles to experience solitude in remote wilderness areas. Yet, recreational trips are vitally important as a generator of economic prosperity, traffic congestion, and environmental exploitation. For example, in New Hampshire tourism contributes more than $300 million annually to the state's economy and at the same time adds almost enough overnight guests to double the state's population (13)! Given such economic and traffic consequences, it is imperative that transportation (and recreation) planners be able to predict recreational travel behavior.

In the remainder of this paper the use of disaggregate, probabilistic models will be examined in the context of recreational travel behavior. The requirements of recreational models and the previous research in this area will be assessed. A strategy will then be proposed for using disaggregate, stochastic models to represent recreational travel behavior. Finally, a research program will be suggested for a disaggregate, stochastic recreational travel model.

RECREATIONAL TRAVEL MODELING

Model Criteria

To develop or analyze any modeling effort first requires a determination of what it is that the model should do. What policy questions should be answered by the model? What output quantities are needed? What operational criteria should the model meet? For the case of a recreational travel model, answers to these questions are given below.

Policy Questions
1. What effects on recreational travel and usage will result from changes in either transportation or recreational facilities?
2. What changes will result from changing public tastes (e.g., increased public environmental awareness)?
3. What changes will result from economic changes such as increased fuel cost, discriminatory pricing, or increased fees?
4. What changes will result from increased leisure (e.g., a 4-day work week)?

Model Outputs
1. Recreational usage (user-days) at a given recreation site
2. Recreation trips from origin i to recreation site j

Model Parameters
1. Transportation facilities, recreation supply, recreation demand
2. User characteristics, desires, and perceptions
3. Intervening events (e.g., crowding, weather)

Model Characteristics
1. Predict travel for several time scales (annual, seasonal, weekend)
2. Represent competition among recreation sites
3. Account for multipurpose and multidestination journeys
4. Classify trips by purpose
5. Consider individual travelers

The policy issues reflect the broad societal importance of recreational travel. It is important not only to know the impact of tourism on highway traffic or on the park environment but also to have answers to social and economic questions. For example, what segments of the population use public park facilities and how can fair management policies be determined to avoid discrimination against user groups while preventing destructive overuse of an area? [That problem is now being faced in the Boundary Waters Canoe Area in Minnesota (10).] On a more pecuniary level is the question of how rising fuel costs will affect recreational incomes, a question recently addressed by the New Hampshire House of Representatives and perhaps by other state governments.

Previous Research

Recreational travel research has focused on 2 major topics: predicting the demand for recreation (trip generation) and predicting where a recreationist will go (trip distribution). Although the analogy to urban transportation planning is apparently strong, such is not necessarily the case. Much of the demand analysis research has been done by recreation planners and social scientists concerned with the use of a particular site or with population participation characteristics and not with the resulting highway traffic.

Recreational demand research may be divided into 2 categories: site specific and user specific. The former is very common; it may involve a single location (16, 24) or a group of locations (5, 12). Many state recreation plans are in the latter classification. [Chubb (2) provides a review of the methodologies used in many state recreation plans.] Often, site-specific demand research is mathematically simple and involves extrapolation techniques or regression of attendance against time and perhaps other independent variables. The objective of this research has sometimes been to estimate the benefits of a recreational site (4, 15, 25), but commonly the objective has been to predict future consumption of recreation at the site. This point is important in that the word "demand" has often been used mistakenly; for, as Tadros and Kalter (29) point out, projections are often made without knowing the effects of costs on the projections. A notable exception to this tendency has been the approach of Clawson and Knetsch in using travel costs to develop demand curves.

User-specific demand research followed primarily from 2 national recreation surveys: the Outdoor Recreation Resources Review Commission survey in 1960-61 and the Bureau of Outdoor Recreation survey in 1965. After these surveys, a number of analyses were performed to develop methods of predicting recreational demand. These analyses show income and age to be the primary variables in explaining recreational participation. Pertinent to the disaggregate, probabilistic model described in the next section of this paper is the fact that recent analyses of these survey data have yielded a 2-equation demand prediction method. The first equation estimates the probability that a person participates in a given recreational activity, and the second estimates the amount of time he or she will participate. A thorough review of this national survey-based research is presented by Cicchetti (3). Examples of other user-specific demand prediction efforts include Ungar's (31) "activity index" for state park campers, Vickerman's (32) non-work-trip generation models, and LaPage's (17) and Hoffman and Romsa's (14) analyses of private campground users.

The distribution of recreational trips has been less common than the prediction of recreational demand. A few studies have used models such as regression analysis (9), cross classification (6), and linear programming (29), but most studies have used the gravity model (8, 31, 34), the intervening opportunities model (22), or an electrical analog model called the systems theory model (2, 7, 8, 11). For each of these latter 3 types of models, the modeling approach is essentially the same: Total trips emanating from origins (often counties) are estimated; a highway network is coded; and the attraction of each possible recreation site is estimated. The trip generation step follows directly from the demand analysis already described. However, the attractiveness of a recreational site is more difficult to determine. Most attempts at measuring attractiveness have used an attractiveness index, that is, a score given to a site depending on the facilities it offers. The methods used in determining these scores have often been subjective (2, 7), although some indexes have resulted from careful analyses of user preferences for facilities (8, 31).

These trip distribution models marked a significant advance in recreational planning methodology. As Chubb (2) demonstrates in his review of state recreation plans, most recreation planning has been done without consideration of the transportation network that connects recreation sites with the problem demanding recreation opportunities. Thus, these distribution models for the first time considered simultaneously and explicitly the 3 factors determining recreational travel: recreational supply and demand and the highway network connecting them.

Yet, the models have many deficiencies. Notwithstanding the need to measure attractiveness and the fact that the time scale used is a year or a season, the models treat user characteristics only implicitly by categorizing trip types and by using demand analysis research results to predict trip generation. Thus, just as in modeling urban work trips, aggregation poses a problem. However, in recreation travel models it might be argued that aggregation is even more deleterious. For example, Chubb modeled boaters in Michigan; yet it has been shown that even in a single recreation area boaters vary considerably. [Research by Lucas (18) in the Boundary Waters Canoe Area showed that motorboaters, canoeists, and motorcanoeists display significantly different travel behavior.] Moreover, the increased importance of noneconomic motives in recreational travel decisions suggests that these decisions are even more personalized than those of work trips. By not explicitly considering user characteristics and preferences, the models are unable to deal with factors such as weather, crowding, price and cost changes, and changes in user preferences and perceptions.

DISAGGREGATE APPROACH

The restrictions and requirements of a recreational travel model and the experience with more traditional trip distribution models may cause one to wonder whether disaggregate, probabilistic models offer significant improvements in recreational modeling. To answer this question, we must first determine how such models can be applied to recreational trip-making. What follows is one approach for developing such a disaggregate recreational model.

Proposed Model

Consider the case of extraurban recreational trips to recreational facilities in a region. Initially, consider the seasonal flows of such trips; short-term recreational trips, such as those on weekends, will be discussed later.

It may be argued that recreationists make explicitly or implicitly at least 3 travel decisions: to participate in a given type of extraurban recreation; to engage in this activity with a certain degree of intensity (i.e., numbers of trips); and to choose the sites at which to engage in this activity. For trips outside of a region, mode choice would also be an important decision, but for regional recreation trips the choice of mode is usually more restricted. The discretionary nature of recreation travel is apparent in the second travel decision: Knowing that a person is a skier does not tell how often he travels to ski areas. Thus, the prediction of seasonal recreational trips demands that the number of trips made by a person be explicitly modeled.

A disaggregate, probabilistic recreational travel model may be simply constructed as a multiplicative combination of 3 probabilistic terms. Let $X(i)$, $N_{ij}(n)$, and $D_{ij}(k)$ be defined as follows:

$X(i)$ = probability that a person participates in recreation activity i;
$N_{ij}(n)$ = probability a person makes n annual activity I trips given that he or she participates in activity i; and
$D_{ij}(k)$ = probability a person from city j chooses site k given that he or she undertakes an activity i trip.

In mathematical terms, these definitions become

$$X(i) = P\{X = i\}$$

$$N_{ij}(n) = P\{N_j = n \mid X = i\}$$

$$D_{ij}(k) = P\{D_j = k \mid X = i\}$$

For a resident in city j, these probabilities multiplied together yield the probability that the resident will make n seasonal activity i trips to site k. Thus, the expected number of such trips made in a season t_{ijk} is given by

$$t_{ijk} = X(i)\, D_{ij}(k) \sum_{n} n\, N_{ij}(n) \tag{1}$$

Equation 1 illustrates the disaggregate nature of the model. The 3 travel decisions are each treated in a disaggregate fashion and combined to yield predictions of an individual's travel behavior.

Aggregation occurs by computing the expected value of the seasonal trips made by all city j residents to site k. To compute this quantity, however, one must alter the probability X(i) by making it city specific. That is, X(i) is the probability that a person with given age, income, and other characteristics will participate in activity i. What is needed is the probability that any resident of city j will participate in that activity. Let $X_j(i)$ represent this probability. The expected number of seasonal trips to site k by all city j residents T_{ijk} is given by

$$T_{ijk} = D_{ij}(k) X_j(i) P_j \sum_n n N_{ij}(n) \tag{2}$$

where P_j is the population of city j. Thus, seasonal flows from city j to site k can be predicted if the 3 probabilities $X_j(i)$, $N_{ij}(n)$, and $D_{ij}(k)$ can first be estimated.

Short-term recreational trip-making, such as that during a specific weekend, is much more difficult to model. Although only 2 travel decisions are important in this case (how many trips to take is no longer a relevant decision), the factors influencing these decisions are complex. For example, the decision to undertake a trip on a specific weekend—or on a specific day—depends on factors such as weather, anticipated crowding, distance to available recreation site, the person's previous experience with and commitment to the recreation activity, and his or her socioeconomic characteristics. Thus, trips on specific weekends may be predicted in 1 of 2 ways: Relate the decisions of individuals to these many variables or relate the proportion of seasonal trips that occur on a weekend to the intervening variables such as weather and time of year. Clearly the latter of these methods is the easier, and, although it is not disaggregate in that it does not model individual decisions at a particular point in time, it does rely on the seasonal travel predictions for individuals (Eqs. 1 and 2).

Parameter Estimation

The validity of the model depends, of course, on its ability to relate the 3 input probabilities to demand, supply, transportation, and user characteristics. If the model is to improve on existing models, then these factors must be explicitly incorporated into the process by which these probabilities are estimated.

The $X_j(i)$ probabilities may be derived from the user-specific demand analyses based on the national recreation surveys. The procedure is straightforward. Analyses of these data relate probability of participating in an activity X(i) to socioeconomic data, particularly income and age. Data from these variables for a specific urban area are used to estimate city-specific probabilities $X_j(i)$.

The other 2 probabilities, $N_{ij}(n)$ and $D_{ij}(k)$, are more difficult to estimate. Each of these probabilities refers to choices made among more than 2 alternatives (i.e., number of trips and choice of destinations). These probabilities can be estimated by the use of a multidimensional logit model (21). Clearly, however, the problem of estimating probabilities for a large set of destinations—which may not all be among the choice sets of individual travelers—requires further research.

However, the complexity of recreational travel decision-making is represented not just in the estimation methods chosen but also in the specification of variables to be included in the estimation process. The $N_{ij}(n)$ probability illustrates this point. This probability, which relates to the number of seasonal trips a recreationist makes, is dependent on a number of factors, including the socioeconomic characteristics of the person and the availability of recreational opportunities. Availability may be denoted by travel times to recreation sites for an activity and a variable denoting the supply of sites for this activity. For example, if the activity were camping, the total number of camping places in an area may be included as a variable. This is the procedure followed in the Rutgers University demand analysis that uses national survey data (3). Or both supply and travel time may be combined by constructing concentric rings around a city, summing the facilities in each ring, multiplying by the inverse of travel time to this ring, and summing the products. This procedure produces a weighted recreational accessibility index.

The user characteristics that might be included are numerous. Here the user-specific demand research is helpful in that it has shown age and income to be important indicators of recreation participation. However, these variables are not causal and are not able to represent the psychological motivations underlying recreational travel decisions. One of many ways in which such motivations and perceptions can be included in the model is by measuring a person's "environmental disposition" (19). Environmental disposition is a composite set of scores on environmental factors obtained from a questionnaire called the environmental response inventory. Its use in measuring environmental perceptions has been shown to be valuable in the case of wilderness recreationists (20). It has not yet been used as a variable to explain demand for recreational activities, but it does offer the capability for dealing with policy questions relating to changes in user preferences and perceptions.

The probability $D_{ij}(k)$ requires more variables to describe recreational facilities. The hypothesis in this case is that one site, say, a park, is chosen over another because of park facilities, park location, and user characteristics. However, the inclusion of park facilities immediately raises the question inherent to the trip distribution models already described: How does one measure attractiveness? Many answers are possible depending on the particular activity in question, but data needs will be minimized by using the results of factor analyses of recreational sites, such as those performed by Ellis (7).

Several types of data are required to estimate these 3 probabilities. Origin-destination data describing recreational trips are needed just as they are in the case of other recreational travel models. Also, user characteristics such as age, sex, and environmental disposition are required. Finally site characteristics are needed. This last type of data is already available in many states in the form of state recreational inventories.

CONCLUSION AND RESEARCH RECOMMENDATIONS

Several difficulties with existing recreational trip models have been discussed in this paper. Many of these exist also in the disaggregate probabilities model developed here. For example, neither type of model adequately deals with traffic peaking or multipurpose or multidestination journeys. Also, both models require some measures of recreational facility characteristics or attractiveness.

Yet there are 2 ways in which the disaggregate, probabilistic model offers potentially significant improvements over the existing models. One of these results from the fact that the model is disaggregate. Probabilities are determined for individuals and then aggregated to yield expected trip movements for an entire population. The model is, therefore, at least conceptually able to represent more realistically the variety of recreational trip motivations.

The second advantage relates also to the disaggregate nature of the model. Existing models are unable to incorporate user tastes and perceptions and thus are particularly limited in their predictive value for recreational travel. The disaggregate model, however, can incorporate these factors by including user perceptions such as those represented by a user's environmental disposition. By using this or other measures of user attitudes, one can measure changes in user travel motives and thus predict the resulting effects on recreational travel.

This last point suggests what research is needed to achieve improved predictive capability in recreational travel modeling. One of these steps, of course, is to test the model by estimating the 3 input probabilities; travel data for a variety of recreational activities are used. Just as the exponent in the gravity model varies considerably, as Wolfe (33) discovered, with recreational trip type, the input probabilities in the disaggregate model vary with trip type and experience is needed to determine how they vary. Also, research is needed to determine how best to incorporate the user characteristics and perceptions. What attitude measures are most useful, and how should they be included in the model? Stopher and Lavender (28) show that for mode choice for urban work trips user stratification is the best way to incorporate user characteristics. However, with the additional complexity of trip classification and user attitudes, such stratification may require unreasonable amounts of data.

A second and related research endeavor is also indicated. In the proposed model, probabilities must be estimated for 2 travel decisions made from n-dimensional choice sets. As already mentioned, these estimations encounter both data restrictions and conceptual difficulties resulting from a lack of choice sets common to all recreational travelers. These problems—which are common to the extension of disaggregate models to many other travel decisions as well—require considerable research attention.

Nonetheless, disaggregate models are a welcome and potentially useful addition to recreational travel modeling. What these models represent is a more rational approach to modeling a complex and highly psychologically motivated set of recreational travel decisions. But also, the models present a means of integrating research on user trip patterns, perceptions of recreational environments, and satisfactions with these environments. By so doing, the models will lead to increased capability for dealing with the many complex policy questions facing recreational planning.

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